



INITIAL FINDINGS



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- 72 Hour Vacuum Bake Followed By Sealing RGA Holes (Electrical Performance Normal for all Channels)
- 160 Hour Burn-in @ +85C, DC Bias (1 of 7 channels drifted slightly)
- 96 Hour Bake @ +93C (all channels drifted)
- RGA Testing
 - ◆ Met Internal Water Vapor Content Requirement: 1.7%
 - ◆ Hydrogen: 1776ppm
 - tantalum nitride*
 - hybrid*
 - microelectronics*
 - palladium*



IDENTIFICATION OF PROBLEM



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- Empirical Circuit Analysis Identified two 35k ohm Tantalum Nitride Resistors that set the bias voltage for each side of a LM194 or a MAT02 matched dual NPN transistor to be very sensitive.
- Computer circuit simulation confirmed this finding. A 20 ohm differential shift in the set resistance values between the 2 chips would result in the observed frequency output drifts.
- EDAX Analysis of the 35k ohm thin film Tantalum Nitride chip resistors identified Palladium in the film.
- A catalytic reaction of Palladium and Hydrogen produces mono atomic hydrogen.
- Filled the filter module cavities with a 4% Hydrogen, 96% Nitrogen gas mixture @ 25°C and monitored the electrical performance for 24 hours. Some channels drifted in a similar pattern witnessed earlier.
- An internal visual and EDAX analysis was performed at the conclusion of this testing. Confirmed Palladium on chip resistors.



X-RAY EDS OF TANTALUM NITRIDE RESISTOR



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9-Feb-1999 11:34:40

ELEMENT

Vert=

1000 counts

Disp= 1

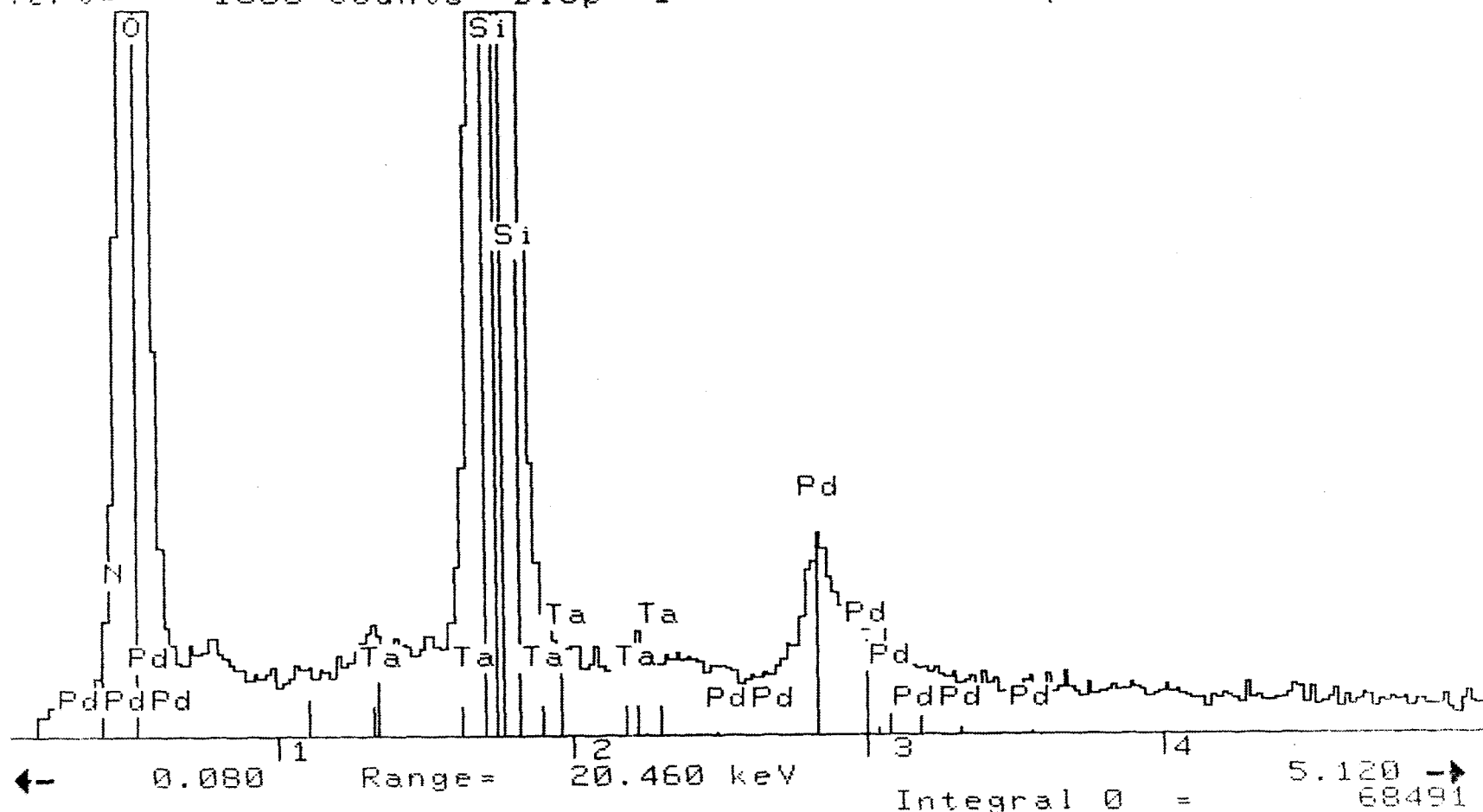
10KV

Preset=

100 secs

Elapsed=

100 secs





HYPOTHESIS



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- When burn-in was performed on hermetically sealed filters at +125°C, hydrogen was desorbed out of the Kovar carriers, epoxy and plated parts and into the air inside each hybrid MIC module.
- A catalytic reaction between the hydrogen and the palladium in the 35k ohm Tantalum Nitride resistors subsequently resulted in slight shifts in their resistance values.
- Due to the design of the analog section, these slight shifts resulted in very large changes in the static output frequency of the filter module channels.



SUPPORTING DATA



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- Final RGA test: 1776ppm Hydrogen, 97.8% Nitrogen, 1.57% Moisture
- Electron Dispersion X-Ray Detector (EDAX) identified Palladium in Tantalum Nitride resistor films.



POST 96 HOUR BAKE RGA DATA



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Hydrogen	0.1775% (1776 PPM)
Nitrogen	97.8073%
Moisture	1.5681% (pass, <5%)
Oxygen	0.2258% (2258 PPM)
Carbon Dioxide	0.1397% (1397 PPM)
Argon	0.0218% (218 PPM)
MEK	0.0540% (540 PPM)
Hydrocarbon	0.0057% (57 PPM)



DRY AIR



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Nitrogen (N ₂)	78.09%	
Oxygen (O ₂)	20.95%	
Argon	0.93%	
CO ₂	0.03%	
Neon	0.0018%	
Helium	0.00052%	
Methane (CH ₄)	0.00011%	
Krypton	0.0001%	
Hydrogen (H₂)	0.00005%	(0.5 PPM)
Ozone (O ₃)	≤0.00005%	
Xenon	0.0000087%	
CO	≤0.00005%	
N ₂ O	0.0000003%	
SO ₂	≥0.0000007%	

Nitric Oxide, Nitrogen Dioxide, Formaldehyde, Ammonia (NH₃)



INITIAL RGA TEST DATA



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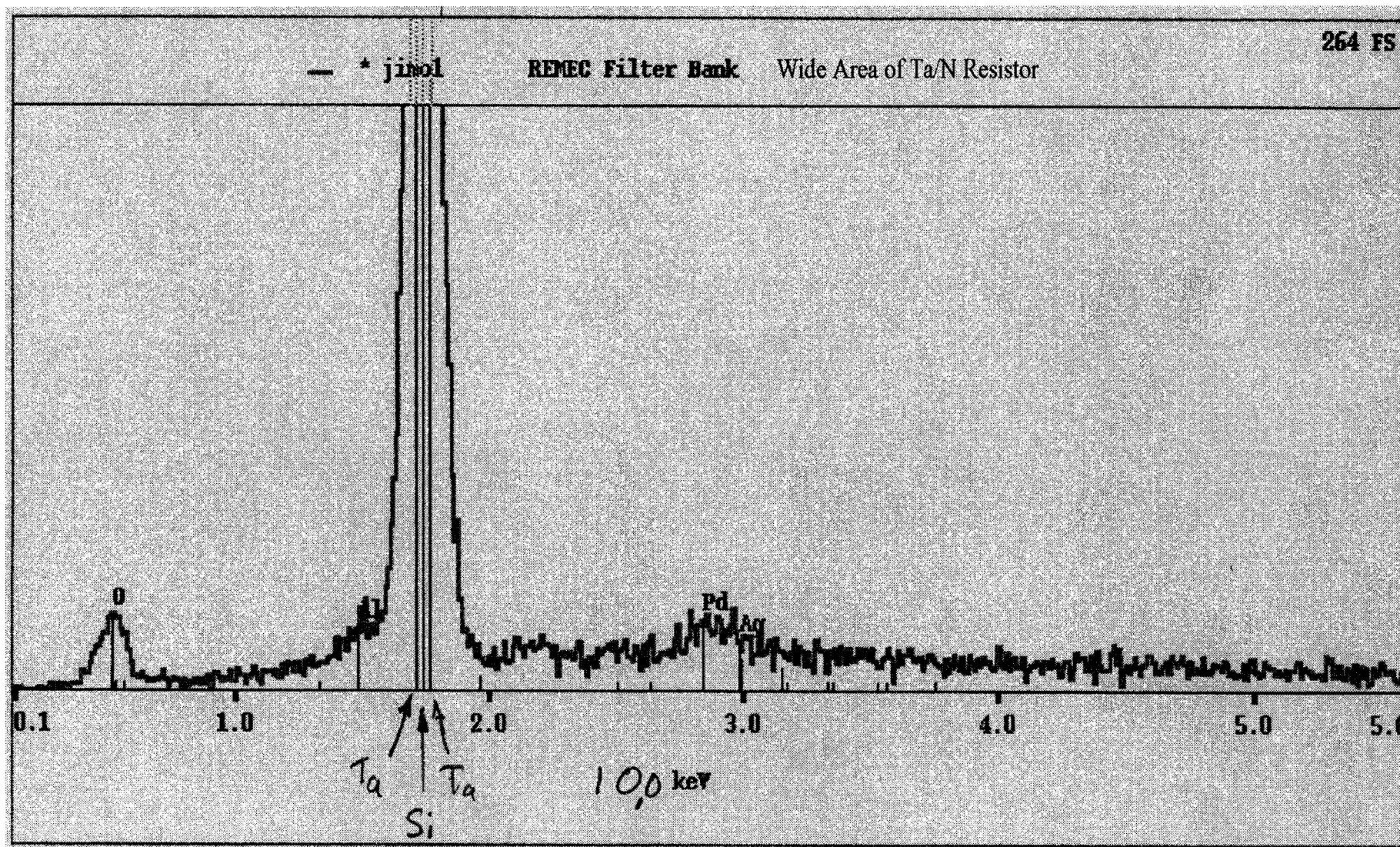
<u>GAS DETECTED</u>	<u>MODULE 1</u>	<u>MODULE 2</u>
Hydrogen	0.4036% (4036ppm)	0.1930% (1930ppm)
Nitrogen	65.7737%	77.6249%
Helium	23.6097%	7.7489%
Moisture	7.9643%	6.7730%
CO2	1.8147%	1.4550%
Oxygen	2747ppm	5.7011%
MEK	886ppm	779ppm
Argon	248ppm	3933ppm
Other: Hydrocarbon, Krypton, THF (all <156ppm)		



X-RAY EDS OF RESISTOR CHIP IN HYBRID



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Effects of Hydrogen, SoCal'99



SOURCES OF HYDROGEN



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- Ferrous Metal Package Materials, trapped in metal at structural imperfections, grain boundaries, precipitate interfaces, dislocation cores. (Cold Rolled Steel, Kovar, Invar)
- Gold and Nickel Plating Process.
- Microwave Absorbers (powdered iron filings suspended in a carrier such as silicone rubber)
- Epoxy is suspected as a source.
- Capacitors, Circulators, Isolators, Ferrite Pucks, Circuit Substrates, Resistors and Metal Films may be sources.



SIGNIFICANT INFORMATION



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- Research theory assumes a catalytic reaction with Palladium and molecular Hydrogen forming mono atomic hydrogen. In GaAs Semiconductors this results in compensation of donors in the channel or a shift in barrier height.
- A 10 to 20 ohm delta shift in resistance value between the two 35k ohm tantalum nitride resistors will result in the observed output drift.
- Modifications as a result of this study, using a center tapped dual tantalum nitride resistor, replacement of Kovar carrier with molybdenum, improved electrical grounding, proper 24 hour pre-seal vacuum bake and the addition of a hydrogen getter.
- Static output frequency has stabilized by a factor >100 times and there is no longer any frequency drift during burn-in testing of the hermetic cavity.



CORRECTIVE ACTION



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- Change Kovar carriers to Copper-Molybdenum.
- Add Hydrogen Getter from Allied Signal Aerospace (HMC Getter) which can maintain hydrogen levels to <1 PPM and the dew point <-100°C
- Open package thermal treatment bake-out at 100 to 110°C.
- Perform 24 hour Vacuum Bake at +85°C prior to welding cover over module in a dry Nitrogen/Helium gas environment.
- Lower Burn-In temperature to +85°C.
- Replace the two 35k ohm single chip Tantalum Nitride resistors with a dual center tap resistor.
- Locate resistors from a supplier that does not use Palladium in their process.
- Maintain hybrid module temperature below +85°C during all post seal process and screening tests.



SUMMARY



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- Isolated Failure Mechanism
- Developed a Hypothesis
- Supported Hypothesis
- Modified Hybrid Design in Accordance With Hypothesis and Other Problems With Circuit.
- Demonstrated new circuit design was now stable.
- Identified new concern with tantalum nitride chip resistors for hydrogen desorbed inside a hermetic microelectronic hybrid device.